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Large Hadron Collider
Magnet Division Procedure

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Class: Dipole
Title: D2/D4 Dipole Shell Welding Assembly

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· ES&H Review: Signature on File

REVISION RECORD

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1 Scope:

This specification describes the procedure for yoke weighing, yoke stacking, and longitudinal seam welding of the D2/D4 LHC Dipole Cold Mass Assemblies.

2 Applicable Documents:

The following documents, of the issue in effect at the time of release for manufacture, form a part of this procedure to the extent specified herein:

RHIC-MAG-Q-1004	Discrepancy Reporting Procedure
RHIC-MAG-Q-1000	Procedure For Control of Measurement Test Equipment
SMD OPM 8.1.1.39	Operation of the LHC Shell Welding Fixture
LHC-MAG-M-1040	Weld Inspections on BNL D2 and D4 Separation Dipoles

BNL Drawings:

14010179	Assembly, LHC D2 Dipole, Shell Welding
14010152	Assembly, LHC D4 Dipole, Shell Welding

3 Requirements:

The Dipole Cold Mass Assembly shall be welded in accordance with this specification and associated drawings.

All welding must be performed by welders qualified in accordance with ASME Section IX.

3.1 Material/Equipment

25-1776.01-5	Shell Weld Fixture Stand Assembly
25-1782.05-5	Lifting Beam Assembly
25-1789.92-2	Lifting Clamp Assembly
25-1807.03-5	Lifting Beam Weldment Assembly (LHC Collared Coil Lifting Beam Assembly)
25-1782.01-5	LHC Cold Mass Lifting Beam Assembly
25-1807.01-5	Shell Lifting Fixture
25-1797.01-5	LHC Yoke Lifting Angle Assembly
25-1717.43-3	Lifting angle Yoke/Shell Assembly

3.2 Safety Precautions

3.2.1 Operators shall be trained by their cognizant technical supervisor and qualified in the operation of the required welding equipment.

3.2.2 No welding shall take place unless all welding screens are in place around the welding station, and all personnel not directly involved with the welding process are outside the screens. Any personnel inside the screens shall wear protective gear to prevent eye injury, and shall be clothed to prevent burns caused by intense ultra-violet light.

3.2.3 All lifting and handling operations requiring overhead crane operations shall be performed by holders of valid Safety Awareness Certificates and trained in the use of the lifting device by the Cognizant Engineer or Technical Supervisor.

3.2.4 Some of the electrical test procedures have specific safety requirements. The technicians performing these specific tests shall rigorously follow all the safety requirements listed as well as those prescribed by the BNL ES&H Standard.

3.2.5 Hypot and impulse testing pose a Class "C" electrocution hazard. At least two properly trained technicians must be present to perform this testing. When testing, a trained technician shall be stationed at any point where the item under test is accessible to unauthorized people, and barriers shall be set up. Signs shall be posted reading "DANGER HIGH VOLTAGE" and warning lights shall be turned on.

3.3 Procedure

3.3.1 Weigh and Stack Lower Yoke

3.3.1.1 On the weight scale, stack end laminations for the NLE to the weight listed in Table 1, using an equal amount of laminations with one notch and laminations with two notches. Record the weight and heat number(s) in the traveler.

3.3.1.2 Transfer the laminations to the rails on the shell welding fixture. Stack laminations in 1 inch blocks alternating between laminations with one notch and laminations with two notches.

NOTE

When stacking laminations be sure all the notches are on the same side.

Table 1. Lamination Weights ± 1.4 lbs.

	D2/D4
LE	484.7
Center	16463.5
NL	325.4

3.3.1.3 Using the weight scale, weigh out center laminations onto 10 separate pallets. Each pallet is to contain one-tenth of the weight shown in Table 1 weighed to the nearest lamination (i.e. 1646.35 lbs. per pallet for a D2 magnet). 5 pallets are to contain "one notch" laminations, the other 5 pallets are to contain "two notch" laminations. Record weights of each pallet.

NOTE

One "one-notch" pallet shall contain 28 "one-notch" modified laminations. One "two-notch" pallet will contain 28 of the "two-notch" modified laminations. These laminations shall be in place of the regular center laminations.

3.3.1.4 Record the total weight of the ten pallets in the traveler. Total weight to agree with Table 1. Adjust number of laminations in last pair of pallets if necessary. Record heat number(s) in the traveler.

3.3.1.5 Transfer one pallet of "one notch" and one pallet of "two notch" laminations to the rails of the shell welding fixture. Stack laminations in 1 inch blocks alternating between laminations with one notch and laminations with two notches.

NOTE

When stacking laminations be sure all the notches are on the same side.

3.3.1.6 After loading the first pair of pallets, use a tape measure to measure distance from NLE of end laminations to laminations stacked in 3.3.1.5. See figure 1. Compare measurement to Table 2. Fluff laminations as required to bring measurement within required dimension and ensure that the end of stack is square to fixture.

	Measurement (6 1/16")
After 1st Pair of Pallets	79 5/8"
2nd	151 9/16"
3rd	223 9/16"
4th	295 1/2"
5th	367 1/2"

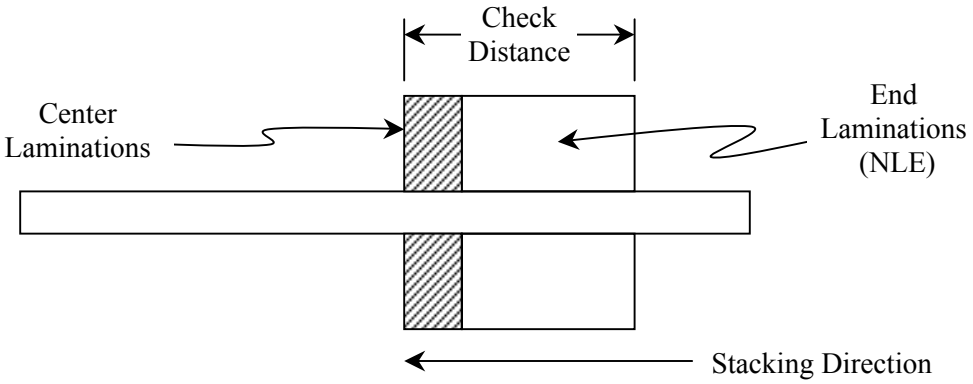

Figure 1

3.3.1.7 Repeat steps 3.3.1.5 - 3.3.1.6 until all ten pallets have been stacked.

NOTE

The pallets containing the modified laminations will be used as the second pair stacked. The modified laminations will begin 187.78" from the end of the NLE laminations (see figure 1). They will be stacked using the same notch alignment convention as that used on the other laminations.

3.3.1.8 On the weight scale, stack end laminations for the LE to the weight listed in Table 1.

3.3.1.9 Record the weight and heat number(s) in the traveler and transfer the laminations to the rails on the shell weld fixture. Stack laminations in 1 inch blocks alternating between laminations with one notch and laminations with two notches.

NOTE

When stacking laminations be sure all the notches are on the same side.

3.3.1.10 Install the fixture stops and tie rods. Tighten to achieve the yoke lengths per the

shell welding assembly drawing.

3.3.2 Collared Coil Installation.

3.3.2.1 Install two NL filler lamination packs in the lower yoke.

3.3.2.2 Using 25-1789.92-2 (with either 25-1807.03-5 or 25-1782.01-5 lifting beams), install the 2 collared coil assemblies into the lower yoke half. Center the collars in the yoke.

NOTE

For D4 assemblies, verify correct collared assembly part numbers are used and that they are properly oriented within the iron. D4 beam tubes point outward at NLE.

3.3.2.3 Install the yoke keys per the shell welding assembly drawing.

3.3.2.4 Install two NL filler lamination packs on the NL end collar packs.

3.3.3 Weigh and stack upper yoke.

3.3.3.1 Place the spacer bars on the lower yoke.

3.3.3.2 Repeat steps 3.3.1.1 - 3.3.1.10 except use standard center laminations in place of modified laminations. Stack the laminations on the spacers above the lower yoke stacking fixture. Position upper yoke so that the notches in the upper yoke laminations are on the same side as the notches in the lower yoke laminations.

3.3.3.3 Using 25-1797.01-5, lift the upper yoke, remove the spacer bars and lower the upper yoke into position on the lower yoke.

3.3.4 Shell Welding

3.3.4.1 Measure and record the shell lengths.

3.3.4.2 Using 25-1807.01-5, place the upper half-shell over the yoke. Center it uniformly about the longest coil. Center it circumferentially relative to the yoke by measuring the height from the weld fixture base plate to the shell edges.

3.3.4.3 Install the backing strips. Center uniformly about the longest coil and secure with a few small tack welds.

3.3.4.4 Clamp the half-shell to the yoke by applying 212 psi maximum to the air cylinders. Again check the edge position relative to the platten surface, verifying that the half-shell is still circumferentially centered after it is fully clamped. Verify with .002 feeler gauges that no gap exists between yoke survey notches and the rails over the entire length.

3.3.4.5 Use c-clamps, located between the cylinders, to draw in the edges of the shell.

3.3.4.6 Make a continuous fuse weld of the backing strip to the lower yoke. Use two certified welders, with one welder on each side of the magnet, remaining in-step along the length, within approximately 6 inches.

3.3.4.7 Fillet weld the upper half shell to the backing strip using 12010441-03. Welds shall be 2" long every 6" on center minimum. Use two certified welders, with one welder on each side of the magnet, remaining in-step along the length, within approximately 6 inches. Start at the lead end and progress to the non-lead end. Leave the last three inches at each end unwelded in order to slide in the end plate later.

3.3.4.8 Unclamp the yoke assembly and remove the air cylinder support assembly. Using 25-1782.01-5 with 25-1717.43-3, lift the upper half shell, yoke and coil assembly and place it on the rotating supports with the lower half shell. Rotate 1800 (the welded half-shell is now down).

3.3.4.9 Using 25-1782.01-5 and appropriate slings, lift the yoke assembly and place it on the support feet. At the shell hole locations, the tooling will fit through holes in the shell, directly engaging the yoke lamination survey flats.

3.3.4.10 Using 25-1807.01-5, temporarily remove the lower half shell.

3.3.4.11 Install the temperature sensors as shown on the assembly drawing. Label temperature sensor wires with Left /Right and sensor serial #. Perform resistance check of temperature sensor as noted in LHC-MAG-R-1051. Record results in traveler.

3.3.4.12 Re-install the lower shell. Center the lower half-shell longitudinally with respect to the upper half-shell. Center it circumferentially relative to the upper half-shell so that a uniform gap exists between the two half-shell edges.

3.3.4.13 Clamp the assembly by applying 212 psi maximum to the air cylinders. Again check the gap between the half-shells and their longitudinally alignment. The clamping must not make the half-shell gap uneven.

3.3.4.14 Check the yoke assembly with .002 feeler stock for full contact with the fixture in all support locations. Use the c-clamps, located between the cylinders to draw in the edges of the shell.

3.3.4.15 Have the weld shop supervisor inspect the magnet and the welding machine settings. Weld shop supervisor must sign traveler before second half shell is tack welded.

3.3.4.16 Make a root pass and cover passes on the weld test sample piece, by MIG welding using hand held MIG guns as will be done on the magnet.

3.3.4.17 Perform x-ray weld inspection on the test sample, LHC-MAG-R-1040. Weld shop supervisor must approve the x-ray results and sign the traveler before the magnet MIG root pass is started.

3.3.4.18 Perform resistance checks as noted in Appendix B, sections 1-2. Record results in traveler.

3.3.4.19 Tack weld the shell halves together using filler wire (P/N 12010441-03). Tacks shall be in the same location as the bottom shell tacks. Use two certified welders, with one welder on each side of the magnet, remaining in-step along the length, within approximately 6 inches. Leave the last three inches at each end unwelded in order to slide-in the end plate later.

3.3.4.20 Make MIG root passes on each longitudinal seam using filler wire (P/N 12010441-02). Use two certified welders, with one welder on each side of the magnet, remaining in-step along the length, within approximately 6 inches. Leave the last three inches at each end unwelded in order to slide-in the end plate later.

3.3.4.21 Have an authorized weld inspector inspect the root pass. Weld inspector must approve root pass and sign the traveler before any further welding is done.

3.3.4.22 Make a cover pass on each longitudinal seam by MIG welding using filler wire (P/N 12010441-02). Use two certified welders, with one welder on each side of the magnet, remaining in-step along the length, within approximately 6 inches. Leave the last three inches at each end unwelded in order to slide-in the end plate later.

3.3.4.23 Have an authorized weld inspector inspect the completed seam weld. Weld inspector must sign the traveler.

3.3.4.24 Unclamp the assembly and remove the air cylinder support assembly.

3.3.4.25 After shell weld has cooled measure and record the shell lengths.

3.3.5 Quench Heater Termination

3.3.5.1 Install the quench heater mounting boards as shown on the assembly drawing.

3.3.5.2 Strip 3.5 inches of insulation from the end of each 22 gauge quench resistor wire. Fold the bare conductors over on themselves to provide a 1.75 inch length to be soldered to the heaters.

3.3.5.3 Strip the insulation from the ends of each quench resistor, fold the bare end of each heater over the ends of the 22 gauge wire and solder as shown on the assembly drawing.

3.3.5.4 Install quench heater clamps as shown on the assembly drawing and secure the wires with lacing cord.

3.3.5.5 Bundle the 4 exiting Quench Resistor wires together and cover entire length with shrink tube.

3.3.6 Electrical Testing

DANGER

Be sure the "Hypot", yoke, and beam tube is grounded at all times. Failure to observe this caution may result in electrocution.

3.3.6.1 Perform a coil-to-coil hypot check at 3 kV, following RHIC-MAG-R-7242.

NOTE

The leakage current must be less than 50 μa.

3.3.6.2 Electrically connect the main coil leads together.

3.3.6.3 Perform a hypot check between the main coils and the yoke at 5 kV, attaching the grounded lead of the hypot tester to the yoke/shell following RHIC-MAG-R-7242.

NOTE

The leakage current must be less than 50 μa.

3.3.6.4 Measure coil temperature. Measure voltage drops across coil at 1 amp DC, following RHIC-MAG-R-7320. Complete the measurements of inductance and quality factor (Q) following RHIC-MAG-R-7228.

3.3.6.5 Perform a hypot check between the collars and each of the quench protection resistors at 5.0kV attaching the grounded lead of the hypot tester to the yoke/shell following RHIC-MAG-R-7242.

NOTE

The leakage current must be less than 50 μa.

3.3.6.6 Perform resistance check of temperature sensors as noted in LHC-MAG-R-1051. Record results in traveler.

3.3.6.7 Perform resistance test on each of two Quench Protection Resistor circuits.

4 Quality Assurance Provisions:

4.1 The Quality Assurance provisions of this procedure require that all assembly and test operations be performed in accordance with the procedural instructions contained herein.

4.2 Measuring and test equipment used for this procedure shall contain a valid calibration label in accordance with RHIC-MAG-Q-1000.

4.3 All discrepancies shall be identified and reported in accordance with RHIC-MAG-Q-1004.

5 Preparation for Delivery:

N/A

Yoke Weight

	Lower	Upper
LE		
Center		
NL		
Total/Half Yoke		
Total/Full Yoke		

Shell Length

	Lower	Upper
Before Welding		
After Welding		

Appendix A

LHC D2/D4 Dipole
Yoke Weight Calculation

Total Yoke Length = 378.89 in.

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- End lamination length LE = 11.396 in
- Center lamination length = 359.845 in.
- End lamination length NL = 7.649 in.

Lamination Surface Area (in^2):

	D2	D4
Center Yoke Lamination	163.300	163.300
End Yoke Lamination	151.823	151.675

Yoke Weight:

Packing factor = 99.0%
Weight = 2x (Lam. Length in. x Lam. Area in^2 x .283 lb/in^3 x .99)

Weight ± 2.8 lbs.	D2/D4
LE Yoke	969.5
Center Yoke	32927.1
NL Yoke	650.7

The ± 2.8 lb. tolerance is based on the weight of a single lamination.

The yoke weights calculated for the LE and NL ends of D4 differ from the D2 values by less than one pound. For simplicity, the D2 values shall be used for both magnets.